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THE

LAND DRAINER'S CALCULATOR.

BY

JOHN EWART.

PRICE ONE SHILLING.

THE

LAND DRAINER'S CALCULATOR.

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JOHN EWART.

THE

LAND DRAINER'S CALCULATOR:

BEING A
MANUAL OF RULES FOR CALCULATIONS INCIDENTAL TO THE
OPERATION OF LAND DRAINING, AND TABLES
OF THE RESULTS OF SUCH AS MOST FREQUENTLY OCCUR IN
PRACTICE.

BY

JOHN EWART,

LAND SURVEYOR AND AGRICULTURAL ARCHITECT AND ENGINEER.

AUTHOR OF A TREATISE
ON FARM BUILDINGS, THE AGRICULTURALISTS' ASSISTANT, A NEW
MODE OF ASCERTAINING THE CARCASE WEIGHT OF
CATTLE BY MEASUREMENT, THE
ARTICLE "MEAT," IN MORTON'S CYCLOPÆDIA OF AGRICULTURE, &C.

BIBLIOTHECA · BODLEIANA ·

LONDON:
HEN[illegible]NUTT, ESTATES' GAZETTE OFFICE, 200, FLEET STREET.
EDINBURGH:
OLIVER AND BOYD.
NEWCASTLE-UPON-TYNE:
A. AND J. M. CARR, DAILY JOURNAL OFFICE, GREY STREET;
WILLIAM DODD, BIGG MARKET;
F. AND W. DODSWORTH, COLLINGWOOD STREET.

1862.

~~180. e. 114.~~
183. e. 45

BIBLIOTHECA·BODLEIANA·
DOMINUS ILLUMINATIO MEA

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PREFACE.

Those who may expect the following pages to contain a treatise on land draining will not find such to be the case. The work is simply what its title page indicates it to be, viz. :—"THE LAND DRAINER'S CALCULATOR;" not in any way professing to give instructions in the practice of draining, but presenting, to the adept in the art, concise rules for calculations incidental to so important an operation in promoting the fertility of the soil; and, whenever the calculations are such as to be frequently required, or where any of the rules require more than a few figures in the rudimentary rules of arithmetic, or in any way complicated in their process, the results are given in tables, for the use of those who may *not* be, and to save trouble to those who may be, proficient in figures.

One of the most frequent causes of error in designing and laying out draining work, is the neglect of the proper adjustment of the size of duct in the lower portion of main or outfall drains, to the rate of fall in such drains, and to the extent of ground to be drained. Where the ducts are larger than the circumstances just mentioned may demand, unnecessary expense will be incurred, not only in the cost price of the ducts, but also in the expense of carriage—perhaps from a considerable distance—of heavier and more bulky material than may be required; and, where the ducts are smaller than such circumstances call for, the draining will be inefficient in its operation. The most important use of the principal table in the following pages, is, to furnish the means by mere inspection, the adjustment already pointed to; and so to obviate the necessity of a calculation, the rule for which, under the most concise form in which it can be given, is tedious to any one, and beyond the educational proficiency of the persons usually engaged in carrying out draining works.

Besides the rule and table already alluded to, all other rules and tables which can be required in estimating the cost of field draining will be found in the present work.

In many of the rules given, the steps in the process of the calculations, as they succeed in logical order, have been bridged over, and the rule reduced to its most concise form, to arrive at the result of its purpose. This, as well as not giving mathematical demonstration of the truth of some, may be deemed, at first sight, a defect in the work; but, when the object of the contents of the work—that of assistance to those who may not be proficient in, or who may be even wholly ignorant of, arithmetic—is for a moment considered, it will be at once perceived that conciseness is rather a merit than a defect, and that mathematical demonstration, under such circumstances, would be wholly useless and out of place.

Should the publication of a transcript from my private note book of the rules and tables given in the present work, for the most part of original construction, be of that use to proprietors of landed estates, land agents, or tenant occupiers of farms, in making estimates of the cost of so important an operation as draining, or in enabling contractors for the work to make correct and reasonable tenders, which, I must confess to the vanity of anticipating, it will be a matter of much gratification to the reader's

Very humble servant,

THE AUTHOR.

Newcastle-upon-Tyne, August, 1862.

THE LAND DRAINER'S CALCULATOR.

OPEN WATER-COURSES.

The best form for the vertical section of an open water-course is a semi-circle, because that figure contains the greatest area within the shortest bounding line; and, consequently, the bounding surface of the channel offers the least resistance, from friction, to the motion of the water. Such a form of water-course is very expensive to construct, and, on that account, very seldom adopted. The forms of open aqueducts most generally in use are those bounded by straight lines; and the best form in such case is when the bounding lines of the rectilinear figure are tangents to a semi-circle, of which the radius is equal to the depth of the water-course.

When the sides and bottoms of a water-course are tangents to a semi-circle of radius equal to the perpendicular depth, the sides, whatever the inclination of their slope may be, are each of them equal to half the breadth of the top. Thus, when the section is rectangular, the breadth will be double the depth; and, when the section is trapezoidal, the slope of the side will exceed the perpendicular depth to the same extent as the perpendicular depth is exceeded by half the breadth of the top; and the breadth of the bottom is always the excess of four times the perpendicular depth over the breadth of the top.

A necessary element in calculating the velocity of streams is what is by some called the *hydraulic depth*, and by others the *radius of section;* and it is the quotient arising from dividing the area of the section of the water-course by its bounding perimeter or sum of the sides and bottom.

The area of a rectangular section is the product of the breadth multiplied by the depth.

The area of a trapezoidal section is the product of half the sum of the breadths of the top and bottom multiplied by the depth.

The area of a semi-circular section is twice the square of the depth multiplied by ·7845.

And the bounding perimeter of a semi-circular section is the product of the depth multiplied by 3·1416.

When the section of a water-course is a semi-circle, or, when bounded by straight lines, which are tangents to a semi-circle, of which the radius is the depth, the *hydraulic depth or radius of section* spoken of is always one-half the depth of the water-course.

EXAMPLES.

Let the depth of a semi-circular water-course be two feet; required, the *hydraulic depth* or *radius of the section?*

Twice the square of 2 is 8, which multiplied by ·7854 is 6·2832 feet, the area of the section of the water-course; then 2 multiplied by 3·1416 is 6 2832 feet, the perimeter of the water-course; and again, the quotient of 6·2832 divided by 6·2832 is 1 foot, the hydraulic depth.

Let the breadth of a rectangular water-course be 4 feet, and its depth be 2 feet; required, the *hydraulic depth* or *radius of the section?*

4 multiplied by 4 is 8 feet, the area of the section of the water-course; then the sum of 2, 2, and 4, is 8 feet, the sum of the sides and bottom of the water-course; and again, the quotient of 8 divided by 8 is 1 foot, the hydraulic depth.

Let the breadth at top of a trapezoidal water-course be 6 feet, its breadth at bottom 2 feet, its perpendicular depth 2 feet, and its sloping sides 3 feet; required, the *hydraulic depth* or *radius of the section?*

Half the sum of 6 and 2 is 4, which multiplied by 2 is 8 feet, the area of the section of the water-course; then the sum of 3, 3, and 2 is 8 feet, the sum of the sides and bottom of the water-course; and again, the quotient of 8 divided by 8 is 1 foot, the hydraulic depth.

The first of the foregoing examples is the case of a water-course of semi-circular section, and the other two are cases in which the bounding lines of the section are tangents to semi-circles, in all of which, it will be seen, the hydraulic depths are one-half the depth of the water-course.

The natural slope or angle of repose of the different kinds of earths are as follows, viz.:—

Clay or strong earth	45	degrees.
Dry sand	40	,,
Sand, less dry	39·6	,,
Common mould	37	,,
Wet gravel	35 to 36	,,

Or the inclination may be stated otherwise:—

Clay or strong earth	1	of base to	1	in height.
Sand	1 2	,,	1	,,
Common mould	1·33	,,	1	,,
Wet gravel	1·43	,,	1	,,

Such are the natural slopes of the earths specified above, but water-courses, even when made in earth of the greatest tenacity, should never have the slope of their sides less than four of base to three in height, unless the bottom and sides be protected by masonry or other means.

The velocity of the stream in a water-course, in feet per minute, is 82½ times the square root of the product of the hydraulic depth in feet, multiplied by the fall in feet per mile.

This rule, however, only strictly applies to a straight course ; but, unless the bends are numerous or very abrupt, the modification required in the result of the rule is so small as scarcely to be appreciable in practice ; and the correction, being somewhat complicated and tedious in its operation, is omitted, as unnecessary to the purpose of the present work.

EXAMPLE.

Suppose a water-course, having the sides and bottom tangents to a semi-circle, the breadth at top to be six feet, the breadth at bottom 2 feet, the depth 2 feet, and the rate of fall found to be 8 feet per mile ; required, the velocity in feet per minute ?

The hydraulic depth, in the case of the present example, is shown by the remark at page 2, to be one foot ; then the product of 8 multiplied by 1 is 8, the square root of which is 2.8, and the product of this, multiplied by 82½, is 231 feet per minute, the velocity required.

The quantity of water a water-course of given dimensions and velocity can discharge is the product of the area of the transverse section multiplied by the velocity. When both quantities are given in feet, and the time of the latter per minute, the result will be in cubic feet per minute, and which, multiplied by

6·23, will give imperial gallons per minute; or, divided by 9·63, imperial gallons per second.

EXAMPLE.

As in the last case:—

The area of the tranverse section of the water-course is, as in page 4, 8 feet, and the velocity, as in the example to the foregoing rule, 231 feet per minute, the product of which two numbers is 1848 cubic feet per minute, and which multiplied by 6·23, gives 11513 imperial gallons per minute, or divided by 9·63, gives 191·9, or nearly 192 imperial gallons per second.

According to the observations of Smeaton:—

Large and deep rivers run sufficiently swift, and discharge vast quantities of water with a descent of one foot per mile.

Small rivers and large burns require about two feet per mile.

Small burns hardly keep an open course under four feet per mile; and ditches, covered drains, &c., require at least eight feet per mile.

In open water-courses the velocity is greatest at the surface, and in the middle of the stream, from which it diminishes towards the bottom and sides, where it is least.

The velocity at the surface of a stream is easily determined by the distance a floating body is carried in a given time, from which the velocity at the bottom may be found by the following rule, the results of which agree with the experiments of Du Buat.

The velocity at the bottom of a stream is the square of the difference between the square root of the velocity in feet per second at the surface, and in the middle of a stream and unity.

EXAMPLE.

The velocity at the surface of a stream is found to be eight feet; required, the velocity at the bottom?

The square root of 8 is 2·8 ; the remainder, on substracting 1, is 1·8, the square of which is 3·24 or 3¼ feet per second, the velocity at the bottom sought.

The mean velocity of the stream in feet per second is half the sum of 8, and 3·24 or 5·62 feet per second.

Besides obtaining sufficient velocity in aqueducts to keep an open course, another and not less important consideration in their construction is to adjust the velocity of currents in *equilibrio* with the tenacity of their channels. In respect to this it has been determined by the experiments of Du Buat and others, that—

A velocity, in inches per second. at the bottom of a stream,	Will move
3	Fine clay.
6	Fine sand.
8	Coarse sand.
12	Water-worn gravel, an inch in diameter.
36	Angular stones, the size of a hen's egg.

In making water-courses, when the earth can be separated by the ordinary grafting tool and shovel, three men will dig and cast 37½ cubic yards of the cut in a day's work of ten hours ; but, when the pick or the maul be required to loosen or break stones, it may require one, or perhaps two, additional men to execute the same quantity of work. When the earth has to be removed by barrows, one man will remove the above-mentioned quantity to a distance of thirty yards on a plank-way in ten hours ; or one horse will remove the same quantity two hundred and twenty yards in eight hours.

COVERED DRAINS, WITH CONDUITS OF TILE PIPES.

The same rules for the velocity and discharge of water apply to cylindrical pipe drains as to open water-courses, already given at page 4. In pipes the depth is to be taken as half, and the hydraulic depth as one-fourth the diameter of the bore of the pipe ; and in the calculation in the present, as in the former case, the hydraulic depth must be expressed in decimals of a foot, the fall in feet and decimals of a foot per mile, and the semi-area of the section of the pipe in square feet.

EXAMPLE.

Required, the velocity and discharge of water in a pipe drain of four inches diameter of bore, and having a fall of fifty-five feet per mile :—

The hydraulic depth for a 4-inch pipe is ·0833 feet, the product of which, multiplied by 55 feet, is 4·5833, the square root of which is 2·14, and the product of which, multiplied by 82½, is 176·55 feet, the velocity sought.

The semi-area of a 4-inch pipe is ·0436 square feet, the product of which, multiplied by 176·55 feet, the velocity found as above, is 7·7 cubic feet, the discharge sought.

As the calculation of this rule is of considerable length, and its application being very important, and of frequent occurrence in practice, its results are given in the following tables for pipes of from 1 to 12 inches diameter of bore, and for falls of from ¼ to 12 inches per statute chain, or from 1 foot 8 inches to 80 feet per mile.

1-INCH=·0833 FOOT BORE.

Hydraulic Depth ·02083 Foot. Semi-Area of Section ·002727 Foot.

FALL.			VELOCITY.	DISCHARGE.
Per Chain In Inches.	Per Mile in Feet.	Per Mile in Inches.	Per Minute in Feet	Per Minute in Cubic Feet.
·25	1	8	17·14	·056
·5	3	4	21·71	·059
·75	5	0	26·6	·072
1·	6	8	30·52	·083
·25	8	4	35·34	·093
·5	10	0	37·62	·102
·75	11	8	40·64	·11
2·	13	4	43·44	·118
·25	15	0	46·08	·125
·5	16	8	48 57	·132
·75	18	4	50·95	·138
3·	20	0	53·24	·145
·25	21	8	55·38	·151
·5	23	4	57·88	·157
·75	25	0	59·49	·162
4·	26	8	61·44	·167
·25	28	4	63 35	·172
·5	30	0	65·17	·177
·75	31	8	66·95	·182
5·	33	4	68·7	·187
·25	35	0	70·6	·192
·5	36	8	71·86	·195
·75	38	4	73·57	·2
6·	40	0	75 47	·205
·25	41	8	76·8	·209
·5	43	4	78·31	·213
·75	45	0	79 81	·217
7.	46	8	81·36	·221
·25	48	4	82·71	·225
·5	50	0	84·13	·229
·75	51	8	85·52	·233
8·	53	4	86·89	·236
·25	55	0	88·27	·24
·5	56	8	89 51	·244
·75	58	4	90·87	·247
9	60	0	92·16	·251
·25	61	8	93·4	·254
·5	63	4	94·68	·258
·75	65	0	95·92	·261
10·	66	8	97·14	·264
·25	68	4	98·34	·268
·5	70	0	99·54	·271
·75	71	8	100·72	·274
11·	73	4	101·9	·277
·25	75	0	102·9	·280
·5	76	8	104·17	·284
·75	78	4	105·3	·287
12·	80	0	106·48	·29

2-INCH = ·1666 FOOT BORE.

Hydraulic depth ·04166 Foot. Semi-Area of Section ·0109 Foot.

FALL.			VELOCITY.	DISCHARGE.
Per Chain in Inches.	Per Mile in Feet.	Per Mile in Inches.	Per Minute in Feet.	Per Minute in Cubic Feet.
·25	1	8	21·74	·236
·5	3	4	30·74	·335
·75	5	0	37·65	·41
1·	6	8	43·48	·473
·25	8	4	48·61	·529
·5	10	0	53·25	·58
·75	11	8	57·52	·626
2·	13	4	61·49	·67
·25	15	0	65·21	·71
·5	16	8	68·75	·749
·75	18	4	72·07	·785
3·	20	0	75·31	·82
·25	21	8	78·38	·854
·5	23	4	81·57	·889
·75	25	0	83·99	·915
4·	26	8	87·35	·952
·25	28	4	89·63	·977
·5	30	0	92·24	1·005
·75	31	8	94·76	1·032
5·	33	4	97·19	1·059
·25	35	0	99·62	1·085
·5	36	8	101·42	1·105
·75	38	4	104·26	1·136
6.	40	0	106·5	1·16
·25	41	8	108·7	1·184
·5	43	4	110·85	1·208
·75	45	0	112·98	1·231
7·	46	8	115·04	1·253
·25	48	4	117·07	1·276
·5	50	0	119·07	1·297
·75	51	8	121·04	1·319
8.	53	4	123·51	1·346
·25	55	0	124·89	1·361
·5	56	8	126·76	1·381
·75	58	4	128·64	1·402
9,	60	0	130·44	1·421
·25	61	8	132·24	1·441
·5	63	4	134·02	1·46
·75	65	0	135·77	1·479
10·	66	8	137·49	1·498
·25	68	4	139·23	1·517
·5	70	0	141·06	1·537
·75	71	8	142·56	1·553
11·	73	4	144·23	1·572
·25	75	0	145·84	1·589
·5	76	8	147·54	1·608
·75	78	4	149·	1·624
12·	80	0	150·62	1·641

3-INCH=·25 FOOT BORE.

Hydraulic Depth ·0625 Foot. Semi-Area of Section ·0245 Foot.

FALL.			VELOCITY.	DISCHARGE.
Per Chain in Inches.	Per Mile in Feet.	Inches.	Per Minute in Feet.	Per Minute in Cubic Feet.
·25	1	8	26 62	·663
·5	3	4	35·55	·871
·75	5	0	46·12	1·129
1·	6	8	53·24	1·304
·25	8	4	59·54	1·458
·5	10	0	65·22	1·597
·75	11	8	70·45	1·726
2·	13	4	75·31	1·845
·25	15	0	79 88	1·957
·5	16	8	84 64	2·073
·75	18	4	88·31	2·163
3·	20	0	92·23	2·258
·25	21	8	96·	2·352
·5	23	4	100·62	2·465
·75	25	0	103·73	2·541
4·	26	8	106·5	2·619
·25	28	4	109·78	2·689
·5	30	0	112 96	2·767
·75	31	8	116·06	2 843
5·	33	4	119·07	2·917
·25	35	0	122 02	2·989
·5	36	8	124·89	3 059
.75	38	4	127·69	3 128
6·	40	0	130·35	3·193
.25	41	8	133·13	3·261
·5	43	4	135·77	3·326
·75	45	0	138·34	3·389
7·	46	8	140·89	3·451
·25	48	4	143·39	3·513
·5	50	0	145·94	3·575
·75	51	8	148·25	3 632
8·	53	4	150·62	3·69
·25	55	0	152·96	3·747
·5	56	8	155·26	3·803
·75	58	4	157·52	3 859
9·	60	0	159·76	3 914
·25	61	8	161·96	3·968
·5	63	4	164·13	4·021
·75	65	0	166·28	4·073
10·	66	8	168·4	4·125
·25	68	4	170·46	4 176
·5	70	0	172·63	4 229
·75	71	8	174·6	4·277
11·	73	4	176 62	4·327
·25	75	0	178·61	4·376
·5	76	8	180·59	4·424
·75	78	4	182·54	4·472
12·	80	0	184 47	4·519

4-INCH=·333 FOOT BORE.

Hydraulic Depth ·0833 Foot. Semi-Area of Section ·0436 Foot.

FALL.			VELOCITY.	DISCHARGE.
Per Chain in Inches.	Per Mile in Feet.	Per Mile in Inches.	Per Minute in Feet.	Per Minute in Cubic Feet.
·25	1	8	33·74	1·34
·5	3	4	43·48	1·895
·75	5	0	53·45	2·321
1·	6	8	61·49	2·681
·25	8	4	68·7	2·987
·5	10	0	75·3	3·283
·75	11	8	81·34	3·546
2·	13	4	87·03	3·794
·25	15	0	92·26	4·022
·5	16	8	97·22	4·238
·75	18	4	101·97	4·445
3·	20	0	106·5	4·643
·25	21	8	110·85	4·833
·5	23	4	115·04	5·015
·75	25	0	119·98	5·191
4·	26	8	122·98	5·362
·25	28	4	126·77	5·642
·5	30	0	130·44	5·687
·75	31	8	134·01	5·843
5.	33	4	137·5	5·994
·25	35	0	140·89	6·142
·5	36	8	144·21	6·287
·75	38	4	147·45	6·428
6·	40	0	150·62	6·567
·25	41	8	153·73	6·692
·5	43	4	157·25	6·856
·75	45	0	159·75	6·965
7·	46	8	162·67	7·092
·25	48	4	165·57	7·218
·5	56	0	168·4	7·342
·75	51	8	171·18	7·463
8·	53	4	173·92	7·583
·25	55	0	176·55	7·7
·5	56	8	179·27	7·816
·75	58	4	181·89	7·93
9·	60	0	184·48	8·043
·25	61	8	187·02	8·154
·5	63	4	189·53	8·263
·75	65	0	192·03	8·372
10·	66	8	194·45	8·478
·25	68	4	196·86	8·583
·5	70	0	199·25	8·687
·75	71	8	201·61	8·8
11·	73	4	204·42	8·913
·25	75	0	206·25	8·992
·5	76	8	208·53	9·081
·75	78	4	210·78	9·190
12·	80	0	213·01	9·287

5 INCH = ·4166 FOOT BORE.

Hydraulic Depth ·11416 Foot. Semi-Area of Section ·06815 Foot.

FALL.			VELOCITY.	DISCHARGE.
Per Chain in Inches.	Per Mile in		Per Minute in Feet.	Per Minute in Cubic Feet.
	Feet.	Inches.		
·25	1	8	34·37	2·343
·5	3	4	48·61	3·313
·75	5	0	59·54	4 058
1·	6	8	65·75	4·686
·25	8	4	76·86	5·239
·5	10	0	84·17	5·738
·75	11	8	90·94	6·199
2·	13	4	97·22	6·628
·25	15	0	103·57	7·066
·5	16	8	108·7	7·01
·75	18	4	114·3	7·792
3·	20	0	119·07	8·117
·25	21	8	123 94	8·449
·5	23	4	128·59	8·768
·75	25	0	133 13	9·075
4·	26	8	137·5	9·373
·25	28	4	141·73	9·661
·5	30	0	145·84	9·941
·75	31	8	149·83	10·214
5·	33	4	153·73	10·479
.25	35	0	157·52	10·738
·5	36	8	161·23	10·991
·75	38	4	164·85	11·238
6·	40	0	168·4	11·479
·25	41	8	171·87	11·716
·5	43	4	175·27	11·948
.75	45	0	178·61	12·176
7·	46	8	181·52	12·374
·25	48	4	185·11	12·619
·5	50	0	188·28	12 835
·75	51	8	191·39	13·047
8·	53	4	194·35	13·248
·25	55	0	197·38	13·455
·5	56	8	200 32	13·656
·75	58	4	203·36	13·863
9·	60	0	205·37	14·
·25	61	8	209·09	14·254
·5	63	4	211·9	14·445
·75	65	0	214·67	14·604
10·	66	8	217·41	14·82
·25	68	4	220·1	15·004
·5	70	0	222·77	15·186
·75	71	8	225·41	15·366
11·	73	4	228·01	15·543
·25	75	0	230·59	15·719
·5	76	8	233·14	15·893
·75	78	4	235·66	16·065
12·	80	0	238·15	16·235

6 INCH = ·5 FOOT BORE.

Hydraulic Depth ·125 Foot. Semi-Area of Section ·09815 Foot.

FALL.			VELOCITY.	DISCHARGE.
Per Chain in Inches.	Per Mile in Feet.	Inches.	Per Minute in Feet.	Per Minute in Cubic Feet.
·25	1	8	37·63	3·694
·5	3	4	53·25	5·228
·75	5	0	65·17	6·396
1·	6	8	75·31	7 393
·25	8	4	84·76	8·321
·5	10	0	93·23	9·154
·75	11	8	99 62	9·78
2·	13	4	106·5	10·456
·25	15	0	112·96	11·091
·5	16	8	119·07	12·69
·75	18	4	124 89	12·261
3·	20	0	130·44	12·806
·25	21	8	135·77	13 329
·5	23	4	140·89	13·832
·75	25	0	145·84	14·317
4·	26	8	150·62	14·787
·25	28	4	155·26	15·245
·5	30	0	159·76	15·684
·75	31	8	164·13	16·114
5·	33	4	168·4	16·532
·25	35	0	172·56	16·941
·5	36	8	176 62	17·339
·75	38	4	180·59	17·729
6·	40	0	184·47	18·11
·25	41	8	188·28	18·484
·5	43	4	192·02	18·852
.75	45	0	195·66	19·207
7·	46	8	199·25	19·561
·25	48	4	202·23	19·854
·5	50	0	206·25	20 248
·75	51	8	209 66	20 583
8·	53	4	213·01	20·912
·25	55	0	216 31	21·236
·5	56	8	219·57	21·555
·75	58	4	222·77	21·87
9·	60	0	225·93	22·181
·25	61	8	229·05	22·487
·5	63	4	232·12	22·79
·75	65	0	235·16	23·086
10·	66	8	238·15	23·381
·25	68	4	241·11	23 671
·5	70	0	244·03	23·958
·75	71	8	246 92	24·242
11·	73	4	249·78	24·522
·25	75	0	252·6	24·815
·5	76	8	255·39	25·073
·75	78	4	258·15	25·344
12·	80	0	260·88	25·612

7-INCH = ·5833 FOOT BORE.

Hydraulic Depth ·14583 Foot. Semi-Area of Section ·1336 Foot.

FALL.			VELOCITY.	DISCHARGE.
Per Chain in Inches.	Per Mile in Feet.	Per Mile in Inches.	Per Minute in Feet.	Per Minute in Cubic Feet.
·25	1	8	40·67	5·434
·5	3	4	50·35	6·727
·75	5	0	70·44	9·411
1·	6	8	81·34	10·867
·25	8	4	92·72	12·388
·5	10	0	99·62	13·31
·75	11	8	107·61	14·376
2·	13	4	115·04	15·369
·25	15	0	122·02	16·301
·5	16	8	128·62	17·183
·75	18	4	134·89	18·022
3·	20	0	140·89	18·823
·25	21	8	146·64	19·592
·5	23	4	152·18	20·331
·75	25	0	157·52	21·045
4·	26	8	162·69	21·735
·25	28	4	167·7	22·404
·5	30	0	172·59	23·058
·75	31	8	177·5	23·715
5·	33	4	181·89	24·301
·25	35	0	186·38	24·901
·5	36	8	190·77	25·487
·75	38	4	195·06	26·06
6·	40	0	199·25	26·62
·25	41	8	203·36	27·169
·5	43	4	206·51	27·59
·75	45	0	211·34	28·235
7·	46	8	215·22	28·753
·25	48	4	219·03	29·262
·5	50	0	222·77	29·762
·75	51	8	226·46	30·256
8·	53	4	230·08	30·738
·25	55	0	233·68	31·215
·5	56	8	237·16	31·684
·75	58	4	240·62	32·147
9·	60	0	244·03	32·713
·25	61	8	247·4	33·053
·5	63	4	250·72	33·496
·75	65	0	254·	33·934
10·	66	8	257·24	34·367
·25	68	4	260·41	34·791
·5	70	0	263·59	35·215
·75	71	8	266·71	35·632
11·	73	4	270·	36·072
·25	75	0	272·83	36·45
·5	76	8	275·86	36·858
·75	78	4	279·13	37·291
12·	80	0	281·89	37·66

8-INCH=·6666 FOOT BORE.

Hydraulic Depth ·166 Foot. Semi-Area of Section ·1745 Foot.

FALL.			VELOCITY.	DISCHARGE.
Per Chain in Inches.	Per Mile in Feet.	Per Mile in Inches.	Per Minute in Feet.	Per Minute in Cubic Feet.
·25	1	8	45·	7·752
·5	3	4	61·49	10·73
·75	5	0	75·31	13·141
1·	6	8	86·95	15·173
·25	8	4	97·22	16·966
·5	10	0	106·51	18·586
·75	11	8	115·04	20·077
2·	13	4	122·98	21·46
·25	15	0	130·43	22·76
·5	16	8	137·5	23·993
·75	18	4	144·21	25·164
3·	20	0	150·62	26·283
·25	21	8	156·77	27·356
·5	23	4	162·69	28·389
·75	25	0	168·36	29 368
4·	26	8	173 92	30·349
·25	28	4	179·27	31·084
·5	30	0	184·47	32·191
·75	31	8	189 53	33·072
5·	33	4	194·05	33·677
·25	35	0	299·25	34·769
·5	36	8	204·22	35 636
·75	38	4	208·55	36·393
6·	40	0	213·01	37·17
·25	41	8	217·24	37·909
·5	43	4	221·71	38·688
·75	45	0	205 93	39·426
7·	46	8	230·08	40·149
·25	48	4	234·15	40·859
·5	50	0	238·15	41·558
·75	51	8	242 09	42·245
8·	53	4	245·97	42·922
·25	55	0	249·78	43·586
·5	56	8	253·53	44·242
·75	58	4	257 23	44·888
9·	60	0	260 88	45·525
·25	61	8	264·48	46·152
·5	63	4	268·03	46·772
·75	65	0	271·54	47·383
10·	66	8	275·	47·987
·25	68	4	278·41	48·583
·5	70	0	281·79	49·172
·75	71	8	285·12	49·754
11·	73	4	288 42	50·129
·25	75	0	291·68	50·9
·5	76	8	294·9	51·46
·75	78	4	298·09	52·017
12·	80	0	301·24	52 567

9 INCH=·75 FOOT BORE.

Hydraulic Depth ·1875 Foot. Semi-Area of Section ·2208 Foot.

FALL.			VELOCITY.	DISCHARGE.
Per Chain in Inches.	Per Mile in Feet.	Inches.	Per Minute in Feet.	Per Minute in Cubic Feet.
·25	1	8	46·11	10·187
·5	3	4	65·92	14·562
·75	5	0	79·88	17·644
1·	6	8	92·24	20·375
·25	8	4	103·12	22·779
·5	10	0	112·96	24·952
·75	11	8	122·01	26 962
2·	13	4	130·44	28·913
·25	15	0	138·35	30·561
·5	16	8	145·84	32 214
·75	18	4	152·95	33·786
·3	20	0	159·76	35·289
·25	21	8	166 28	36·73
·5	23	4	172·56	38·122
·75	25	0	178·6	39·452
4·	26	8	184·47	40·748
·25	28	4	190·15	42·052
·5	30	0	195·66	43·221
·75	31	8	201·02	44·406
5·	33	4	207·13	45 752
·25	35	0	211·34	46·683
·5	36	8	216·31	47·782
·75	38	4	221·17	48 856
6·	40	0	225·93	49·907
·25	41	8	230 59	50·935
·5	43	4	235 16	51·944
·75	45	0	239 64	52·934
7·	46	8	244·04	53 905
·25	48	4	248·36	54·859
·5	50	0	252·6	55·797
·75	51	8	256·77	56·719
8·	53	4	260·88	57·627
·25	55	0	264 95	58·525
·5	56	8	268·92	59·401
·75	58	4	272·84	60·268
9·	60	0	276·71	61·123
·25	61	8	280·53	61·966
·4	63	4	284·29	62·798
·75	65	0	288·01	63·619
10·	66	8	291·68	64 429
·25	68	4	295·31	65 232
·5	70	0	298·88	66 021
·75	71	8	302·42	66·801
11·	73	4	305·91	67·573
·25	75	0	309 37	68·337
·5	76	8	312 79	69 092
·75	78	4	316·17	69·839
12·	80	0	319·52	70·576

10-INCH = ·833 FOOT BORE.

Hydraulic Depth ·20833 Foot. Semi-Area of Section ·2727 Foot.

FALL			VELOCITY.	DISCHARGE.
Per Chain in Inches.	Per Mile in Feet.	Per Mile in Inches.	Per Minute in Feet.	Per Minute in Cubic Feet.
·25	1	8	48·61	13·256
·5	3	4	68·75	18·748
·75	5	0	84·2	22·961
1·	6	8	97·32	26·551
·25	8	4	108·7	29·643
·5	10	0	119·07	32·172
·75	11	8	128·52	35·027
2·	13	4	137·5	37·496
·25	15	0	145·84	39·77
·5	16	8	153·73	42·022
·75	18	4	161·23	43·918
3·	20	0	168·4	45·923
·25	21	8	175·28	47·798
·5	23	4	181·89	49·6
·75	25	0	188·2	51·353
4·	26	8	194·45	52·807
·25	28	4	200·43	54·659
·5	30	0	206·25	56·244
·75	31	8	211·9	57·786
5·	33	4	217·4	59·286
·25	35	0	222·76	60·747
·5	36	8	228·01	62·18
·75	38	4	233·14	63·578
6·	40	0	238·15	64·945
·25	41	8	243·06	66·284
·5	43	4	248·01	67·632
·75	45	0	252·6	68·885
7·	46	8	257·23	70·149
·25	48	4	261·79	71·39
·5	50	0	266·26	72·61
·75	51	8	270·66	73·811
8·	53	4	274·97	74·986
·25	55	0	279·26	76·155
·5	56	8	283·46	77·3
·75	58	4	287·6	78·428
9·	60	0	291·68	79·541
·25	61	8	295·7	80·639
·5	63	4	299·67	81·721
·75	65	0	303·59	82·789
10·	66	8	307·46	83·844
·25	68	4	311·27	84·885
·5	70	0	315·05	85·914
·75	71	8	318·82	86·943
11·	73	4	322·46	87·936
·25	75	0	326·11	88·93
·5	76	8	329·71	89·912
·75	78	4	333·27	90·884
12·	80	0	336·8	91·846

11 INCH=·9166 FOOT BORE.

Hydraulic Depth ·22916 Foot. Semi-Area of Section ·3299 Foot.

FALL.			VELOCITY.	DISCHARGE.
Per Chain in Inches.	Per Mile in Feet.	Inches.	Per Minute in Feet.	Per Minute.in Cubic Feet
·25	1	8	50·99	16·824
·5	3	4	72·1	23·787
·75	5	0	88·31	29·133
1·	6	8	101·96	33·637
·25	8	4	114·	37·611
·5	10	0	124·89	41·202
·75	11	8	134·89	44 502
2·	13	4	144·21	47 574
·25	15	0	152 96	50·431
·5	16	8	161·23	53·19
·75	18	4	169·09	55·784
3·	20	0	176·62	58·266
·25	21	8	183·83	60 646
·5	23	4	190·77	62 936
·75	25	0	197·47	65·145
4·	26	8	203·94	67·282
·25	28	4	210·22	69·352
·5	30	0	216·31	71·363
·75	31	8	222 24	73·318
5·	33	4	228·01	75·223
·25	35	0	233·64	77 081
·5	36	8	239·27	78·935
·75	38	4	244·52	80·667
6·	40	0	249·78	82·403
·25	41	8	254 93	84·102
·5	43	4	260 47	85·931
·75	45	0	264·93	87·401
7·	46	8	269·79	89·004
·25	48	4	274·56	90·58
·5	50	0	279 26	92·129
·75	51	8	283·89	93 655
8·	53	4	288·42	95·15
·25	55	0	292 89	96·625
·5	56	8	297·3	98·079
·75	58	4	301·64	99·51
9·	60	0	305·22	100·695
·25	61	8	310·13	102·314
·5	63	4	314·29	103·685
·75	65	0	318·41	105·043
10·	66	8	322·46	106·381
·25	68	4	326·47	107·702
·5	70	0	330 43	109 009
·75	71	8	334 39	110·315
11·	73	4	338·2	111·573
·25	75	0	342·02	112·834
·5	76	8	345 8	114·081
·75	78	4	349 54	115·315
12·	80	0	353·24	116·535

12 INCH = 1 FOOT BORE.

Hydraulic Depth ·25 Foot. Semi-Area of Section ·3927 Foot.

FALL.			VELOCITY.	DISCHARGE.
Per Chain in Inches.	Per Mile in Feet.	Inches.	Per Minute in Feet.	Per Minute in Cubic Feet.
·25	1	8	53·25	20·912
·5	3	4	75·31	29·575
·75	5	0	92·23	36·22
1·	6	8	106·5	41·825
·25	8	4	119·07	46·762
·5	10	0	130·44	51·225
·75	11	8	140·89	55·329
2·	13	4	150·62	59·149
·25	15	0	159·76	62·738
·5	16	8	168·4	66·131
·75	18	4	176·56	69·336
3·	20	0	184·47	72·443
·25	21	8	192·	75·401
·5	23	4	199·25	78·258
·75	25	0	206·25	80·994
4·	26	8	213·02	83·653
·25	28	4	219·57	86·225
·5	30	0	225·93	88·725
·75	31	8	232·12	91·156
5·	33	4	238·15	93·554
·25	35	0	244·03	95·833
·5	36	8	249·78	98·089
·75	38	4	255·39	100·293
6·	40	0	260·88	102·451
·25	41	8	266·26	104·763
·5	43	4	271·54	106·634
.75	45	0	276·71	108·766
7·	46	8	281·79	110·659
·25	48	4	286·78	112·619
·5	50	0	291·68	114·542
·75	51	8	296·5	116·436
8·	53	4	301·24	118·299
·25	55	0	305·91	120·134
·5	56	8	310·51	121·94
·75	58	4	315·05	123·721
9·	60	0	319·52	125·475
·25	61	8	323·92	127·206
·5	63	4	328·27	128·914
·75	65	0	332·56	130·6
10·	66	8	336·8	132·263
·25	68	4	340·98	133·906
·5	70	0	345·11	135·528
·75	71	8	349·21	137·135
11·	73	4	353·24	138·718
·25	75	0	357·23	140·336
·5	76	8	361·18	141·838
·75	78	4	365·08	143·369
12·	80	0	369·09	144·942

An important purpose of the foregoing table is to adjust the size of pipe for an outfall drain to any given extent of ground and fall. To understand this, it will only be necessary to bear in mind that one-tenth of an inch of rain-fall on an acre is exactly 363 cubic feet of water; and in 24 hours there are 1440 minutes. Thus the discharge of a pipe drain is the extent of ground from which a pipe drain, of a given size and fall, will discharge a quantity of water equivalent to a rain-fall of four-tenths of an inch in depth, in 24 hours and 12 minutes, which, for practical purposes, may be taken as twenty-four hours. A greater quantity of water, it may be remarked, is very rarely, if ever, required in the climate of the British Islands to be discharged from the soil in 24 hours; so that the quantities in the column in the table under the head of "DISCHARGED" may generally be taken to represent the extent of ground in acres, to which the pipe for an outfall drain, with a given fall, should be applied. If any other depth of rain-fall be required to be provided for than 4-10ths of an inch, then the quantity of ground, to which an outfall drain is to be applied, has only to be multiplied by the number of tenths of an inch of rainfall for which provision is to be made, and the product to be divided by 4; then the size of pipe corresponding in the table to the given fall, and the discharge equal to the results of the foregoing calculation is that required in the case.

EXAMPLE.

Required, the size of pipe needed in an outfall drain having a fall at the rate of 35 feet per mile, to discharge 4-10ths of an inch of rain-fall in 24 hours from 10 acres of ground?

On searching the table it will be found that with a fall of 35 feet per mile a 5-inch pipe will discharge 10·738 cubic feet of water per minute, and as it has been already remarked that such discharge is that of the same number of acres of ground relieved of water equal to 4-10ths of an inch of rain-fall, so that a 5-inch pipe is amply sufficient for the case required.

EXAMPLE.

Required, the size of pipe which should be used in an outfall drain having a fall at the rate of fifty feet per mile, to discharge six-tenths of an inch of rain-fall in 24 hours from 15 acres of ground?

The product of 15 multiplied by 6 is 90, which divided by 4, the quotient, is 22½; the next higher number in the table corresponding to a fall of 50 feet per mile is 29·762, and which is for a pipe of 7-inch bore, which is more than sufficient for the purpose of the case; yet as a 6-inch pipe with the same fall only gives a discharge 20·248, it would be insufficient for the purpose.

It should be remarked that the whole length of a main drain need not have pipes of the size required at its outfall, and that drains should have the size of their pipes diminished in proceeding from their outfalls to their heads, unless where the rate of fall may become diminished.

The statute or Gunter chain is 66 feet in length, and is divided into 100 links; consequently each link is ·66 foot, or 7·92 inches in length.

To convert chains and links into feet. Multiply the number of links by 66, strike off two figures from the right, and the remaining figures to the left will be feet.

To convert feet into chains and links. Divide the number of feet by 66, the whole numbers in the quotient will be chains, and the two first places of decimals links.

The following table will facilitate the converting of links into feet or feet into links.

LINKS.	FEET.
1	·66
2	1·32
3	1·98
4	2·64
5	3·3
6	3·96
7	4·62
8	5·28
9	5·94
10	6·6
20	13·2
30	19·8
40	26·4
50	33·
60	39·6
76	46·2
80	52·8
90	59·4
100 or 1 chain	66·

FEET.	LINKS.
1	1·5151
2	3·0303
3	4·5454
4	6·0606
5	7·5757
6	9·0909
7	10·6060
8	12·1212
9	13·6363
10	15·1515
20	30·303
30	45·4545
40	60·606
50	75·7575
60	90·909
70	106·0606
80	121·2121
90	136·3636
100	151·5151

EXAMPLES of the use of the foregoing table.

Required, the number of feet in 673 links?

In 100 links are....................66 feet
6

In 600 „ „ .... 396 „
„ 70 „ „ .... 46·2 „
„ 3 „ „ .... 1·98 „

„ 673 „ „ ....444·18 „

Required, the number of links in 834 feet?

In 100 feet are	....	151 5151 links
		8
,, 800 ,, ,,	....	1212·1212 ,,
,, 30 ,, ,,	....	45·4545 ,,
,, 4 ,, ,,	....	6·0606 ,,
,, 834 ,, ,,	....	1263·6363

or 12 chains 63 links.

Having given the distance apart in feet of parallel collecting drains, to find the length of such drains in statute chains per acre. Divide 660 by the given distance apart, and the quotient is the length required.

Having the distance apart in links to find the length in statute chains per acre. Divide 1000 by the number of links apart, and the quotient is the length required.

EXAMPLES.

Required, the length in chains of parallel collecting drains made at 18 feet apart in a statute acre?

The quotient arising from 660 being divided by 18 is 36·66 chains, the length sought.

Required the length in chains per statute acre of parallel collecting drains at 40 links apart.

The quotient arising from 1000 being divided by 40 is 25·00 chains, the length sought.

To find the number of pipes required for a statute chain of drain. Divide 792, the number of inches in a statute chain, by the length of the pipes in inches, and the quotient is the number required.

Drain pipes are made by machine, of from 1 to 12 inches diameter of bore, and those of 1 inch to 6 inches inclusive, from 12 to 15 inches in length, but those above 6 inches bore never exceed 12 inches in length.

Lengths of pipes in inches	12	13	14	15
Number required for a statute chain	66	60	56	53

Table showing the length of drain in statute chains, and the number of pipes, of 13 *inches in length, required for a statute acre, the drains being any distance apart, from* 12 *to* 66 *feet.*

Distance apart of Drains in Feet.	Length of Drain per Acre in Chains.	Number of Pipes per Acre.	Distance apart of Drains in Feet.	Length of Drain per Acre in Chains.	Number of Pipes per Acre.
12	55·00	3300	40	16·50	990
13	50·77	3046	41	16·09	965
14	47·14	2828	42	15·71	942
15	44·00	2640	43	15·34	920
16	41·25	2475	44	15·00	900
16½	40·00	2400	45	14·66	884
17	38·82	2329	46	14·35	861
18	36·66	2209	47	14·04	842
19	34·74	2084	48	13·75	825
20	33·00	1980	49	13·47	808
21	31·43	1885	49½	13·33	802
22	30·00	1800	50	13·20	792
23	28·70	1722	51	12·94	776
24	27·50	1650	52	12·69	761
25	26·40	1584	53	12·45	747
26	25·38	1522	54	12·22	733
27	24·44	1466	55	12·00	720
28	23·57	1414	56	11·78	706
29	22·76	1365	57	11·57	694
30	22·00	1320	58	11·38	682
31	21·29	1277	59	11·19	671
32	20·62	1237	60	11·00	660
33	20·00	1200	61	10·82	649
34	19·42	1165	62	10·64	638
35	18·85	1131	63	10·47	628
36	18·33	1100	64	10·31	618
37	17·83	1069	65	10·15	609
38	17·37	1042	66	10·00	600
39	16·92	1015			

Table shewing the length of drain in statute chains, and the number of pipes, of 13 *inches in length, required for a statute acre, the drains being any distance apart, from* 20 *to* 100 *links.*

Distance apart of Drains in Links	Length of Drain per Acre in Chains.	Number of Pipes per Acre.	Distance apart of Drains in Links.	Length of Drain per Acre in Chains.	Number of Pipes per Acre.
20	50·00	3000	61	16 39	983
21	47·77	2866	62	16·13	967
22	45·45	2727	63	15·87	952
23	43 48	2608	64	15·62	937
24	41·66	2500	65	15·38	922
25	40·00	2400	66	15 15	909
26	38·46	2307	67	14·92	895
27	37 03	2221	68	14·70	882
28	35·71	2142	69	14·49	869
29	34·48	2068	70	14·28	857
30	33 33	2000	71	14 08	844
31	32 26	1935	72	13·88	833
32	31·25	1875	73	13·70	822
33	30 30	1818	74	13·51	810
34	29·11	1746	75	13·33	800
35	28·57	1714	76	13·16	789
36	27·77	1666	77	12·98	778
37	27·02	1621	78	12·82	769
38	26·31	1578	79	12 65	759
39	25·64	1538	80	12·50	750
40	25·00	1500	81	12·34	740
41	24·39	1463	82	12·19	731
42	23·81	1428	83	12·05	723
43	23·25	1395	84	11·90	714
44	22·72	1363	85	11·76	705
45	22 22	1333	86	11·62	697
46	21·74	1304	87	11·48	788
47	21·27	1276	88	11·36	781
48	20·83	1249	89	11·23	673
49	20·40	1224	90	11·11	666
50	20·00	1200	91	10 99	659
51	19·60	1176	92	10·87	652
52	19·23	1153	93	10·74	644
53	19·03	1142	94	10·64	638
54	18 52	1111	95	10 52	631
55	18·18	1090	96	10·42	625
56	17·85	1071	97	10 31	618
57	17·54	1052	98	10·20	612
58	17·24	1034	99	10·10	606
59	16 95	1017	100	10·00	600
60	16 63	1000			

The following is a *table of the number of pipes* of different sizes, which can be carried on an agricultural cart drawn by one horse, two horses and two carts being supposed to be driven by one man. The first column of numbers of pipes being that contained in a tumbril with shelvings, and the other that in a long harvest cart.

SIZE OF PIPES.	NUMBER OF PIPES.
1 inch	900 to 1200
2 ,,	500 ,, 750
3 ,,	300 ,, 500
4 ,,	250 ,, 400
5 ,,	200 ,, 350
6 ,,	150 ,, 180
7 ,,	100 ,, 150
8 ,,	70 ,, 100
9 ,,	50 ,, 80

Tile pipes of the same length, bore, and thickness are by no means of uniform weight, but the weights given in the following table will be found to be an average, for such as are made of proper earth for the purpose, and well dried and burnt.

Weights per 1000 *of different sizes of cylindrical tile pipes* :—

Bore.	Thick.	Weight of Pipes per 1000.			
		12 In. long.	13 In. long.	14 In. long.	15 In. long.
Inch.	Inch.	Cwts.	Cwts.	Cwts.	Cwts.
1	¼	11½	12½	13½	14½
2	⅜	17	18½	20	21½
3	½	34¼	37¼	40	43
4	½	45¾	49½	53½	57¼
5	⅝	71½	77½	83½	89½
6	¾	103	111½	120	128½
7	¾	120	...	...	...
8	⅞	160	...	...	...
9	⅞	180	...	...	...
10	1	228	...	...	...
11	1	251½	...	...	...
12	1	274¼	...	...	...

Table of labour in a man's day's work, and decimal of a day's work, required in the several operations, and total work, in executing one statute chain of drain, from 2½ to 7 feet in depth :—

Depth of Drain.	Digging Drain,	Laying Pipes.	Filling Drain.	Total.
Feet.	Day's Work.	Day's Work.	Day's Work.	Day's Work.
2½	·3391	·0419	·0679	·4489
3	·5471	·0419	·1094	·6984
4	·8384	·0419	·1676	1·0479
5	1·7875	·045	·3575	2·19
6	1·9481	·0523	·3896	2·39
7	2·1684	·063	·4336	2 665

In the construction of the foregoing table, the workmen employed are supposed to be able-bodied men accustomed to the work, and the earth such as to be capable of being separated by the grafting spade or ordinary draining tool. Should the earth be strong, and require the use of picks in its separation, or be otherwise more than ordinarily difficult to be removed, the time assigned in the table for digging a statute chain of drain should be increased one-third, and, in some cases, one-half, according to the degree of the extraordinary difficulty of the work.

EXAMPLES
OF THE USE OF THE LAST FOREGOING TABLE.

Suppose the rate of labour to be 3s. per day, it is required what should be the cost of digging and filling drains four feet deep per statute chain ?

Opposite 4 feet in the table the factors are ·8384 for digging and ·1676 for filling, the sum of which is 1·006 ; and which, multiplied by 3, the product is 3,018, or about 3s. per chain for the work in question.

Suppose the draining to be three feet deep, how much should be given per statute chain for digging, laying pipes, and filling the drains, so that the workmen may earn 3s. per day?

In the table under the column "total," opposite to three feet in depth, is ·6984 as the time of a man's day's work in completing a chain length of drain at the depth named, the product of which, when multiplied by three, is 2·0952, or about 2s. 1d. for the price sought.

The quantity of water in one inch in depth of rain-fall on an imperial acre of surface is 3630 cubic feet, 22622·523 imperial gallons, or 101·28 tons.

According to the experiments of M. Schubler, the water contained in one foot of the undermentioned earths, when saturated, is as follows, viz. :—

Calcareous Sand	31·8 lbs.
Siliceous Sand	27·3 „
Sandy Clay	38·8 „
Loamy Clay	41·4 „
Stiff Clay or Brick Earth	45·4 „
Pure Grey Clay	48·3 „
Pipe Clay	47·4 „
Garden Mould	48·4 „
Arable Soil	40·8 „
Fine Slaty Marl	35·6 „
Gypsum Powder	27·4 „
Fine Carbonate of Lime	47·4 „
Fine Carbonate of Magnesia	62·5 „

EARTHWORK.

The following tables for earthwork, shewing the number of cubic yards in a lineal perch of 16½ feet of excavation, according to the side slopes, and calculated to the nearest fraction of ¼, ½, and ¾ cubic yards, are inserted in the present work by the kind permission of their author, Mr. Henry Allnutt, late Inspector of Drainage :—

TABLE I.—SLOPES 1 to 1.

Width at bottom	Depth of Excavation in Feet.									
	1 f.	2 f.	3 f.	4 f.	5 f.	6 f.	7 f.	8 f.	9 f.	10f.
Feet.	Cubic yards.	Cubic yards.	Cubic yards.	Cubic yards	Cubic yards.	Cubic yards.	Cubic yards	Cubic yards.	Cubic yards.	Cubic yards.
1	1¼	3½	7¼	12¼	18¼	25½	34	44	55	67
2	1¾	4¾	9	14½	21¼	29¼	38½	48¾	60½	73¼
3	2½	6	10	17	24½	33	42¾	53¾	66	79¼
4	3	7¼	11¾	19½	27½	36¾	47	58½	71½	85½
5	3½	8½	14½	22	30½	40¼	51¼	63½	77	91½
6	4¼	9¾	16½	24½	33½	44	55½	68¼	82½	97¾
7	4¾	11	18¼	26¾	36½	47¼	59¾	73¼	88	103¾
8	5½	12¼	20	29¼	39½	51¼	64	78	93½	110
9	6	13½	22	31¾	42¾	55	68½	83	99	116
10	6¾	14½	23¾	34¼	45¾	58½	72½	88	104½	122

TABLE II.—SLOPES ¾ to 1,

Width at bottom	Depth of Excavation in Feet.									
	1 f.	2 f.	3 f.	4 f.	5 f.	6 f.	7 f.	8 f.	9 f.	10f.
Feet.	Cubic yards.	Cubic yards.	Cubic yards	Cubic yards.	Cubic yards.	Cubic yards.	Cubic yards	Cubic yards.	Cubic yards.	Cubic yards
1	1	3	6	9¾	14½	20¼	26¾	34	42½	52
2	1½	4¼	7¾	12¼	17½	23¾	31	39	48	58
3	2¼	5½	9½	14½	20½	27½	35¼	44	53½	64
4	3	6¾	11½	17	23½	31¼	39½	48¾	59	70¼
5	3½	8	13¼	19½	26¾	34¾	44	53¾	64½	76½
6	4	9	15	22	29¾	38½	48	58½	70	82½
5	4¾	10½	17	24¼	32¾	42¼	52½	63½	75½	88½
8	5¼	11½	18¾	26¾	36	45¾	56¾	68½	81	94¾
9	6	12¾	20½	29¼	39	49½	61	73¼	86½	100¾
10	6½	14	22½	31¾	42	53	65¼	78¼	92	107

TABLE III.—SLOPES ½ to 1.

Width at bottom	Depth of Excavation in Feet.									
	1 f.	2 f.	3 f.	4 f.	5 f.	6 f.	7 f.	8 f.	9 f.	10f.
Feet.	Cubic yards.	Cubic yards.	Cubic yards.	Cubic yards.	Cubic yards.	Cubic yards.	Cubic yards.	Cubic yards.	Cubic yards.	Cubic yards.
1	0¾	2½	4½	7¼	10¾	14½	19¼	23½	30¼	36½
2	1½	3½	6½	9¾	13¾	18¼	23½	29¼	35¾	42¾
3	2	4¾	8¼	12	16¾	22	27¾	34¼	41½	48¾
4	2¾	6	10	14½	20	25½	32	39	46¾	55
5	3¼	7¼	11¾	17	23	29¼	36½	44	52¼	61
6	4	8½	13¾	19½	26	33	40½	48¾	57¾	67
7	4½	9¾	15½	22	29	36½	45	53¾	63¼	73¼
8	5	11	17½	24½	32	40¼	49¼	58½	68¾	79½
9	5¾	12¼	19¼	26¾	35	44	53½	63½	74¼	85½
10	6¼	13½	21	29¼	38¼	47½	57¾	68½	79¾	91½

TABLE IV.—SIDES PERPENDICULAR.

Width at bottom	Depth of Excavation in Feet.									
	1 f.	2 f.	3 f.	4 f.	5 f.	6 f.	7 f.	8 f.	9 f.	10f.
Feet.	Cubic yards.	Cubic yards.	Cubic yards.	Cubic yards.	Cubic yards.	Cubic yards	Cubic yards.	Cubic yards	Cubic yards.	Cubic yards.
1	0½	1¼	1¾	2½	3	3½	4¼	4¾	5½	6
2	1¼	2½	3½	4¾	6	7¼	8½	9¾	11	12¼
3	1¾	3½	5½	7¼	9	11	12¾	14½	16½	18¼
4	2½	4¾	7¼	9¾	12¼	14½	17	19½	22	24½
5	3	6	9	12¼	15¼	18¼	21¼	24½	27½	30½
6	3½	7¼	11	14½	18¼	22	25½	29¼	33	36½
7	4¼	8½	12¾	17	21¼	25½	29	34¼	38½	42¾
8	4¾	9¾	14½	19½	24½	29¼	34¼	39	44	48¾
9	5½	11	16½	22	27½	33¾	38½	44	49½	56
10	6	12¼	18¼	24½	30½	36½	42¾	48¾	55	61

EXAMPLE.

Required, the number of cubic yards in a main drain, 7 feet deep, and 2 feet wide at bottom, slopes ¾ to 1

Refer to Table II. Find the depth of the drain (7 feet) in the upper or horizontal line of figures, and for the width at bottom (2 feet) look down the vertical column at the side of the table; the intersection of these lines will give 31, the number of cubic yards to be removed in a statute perch (16½ feet running measure).

To find the breadth of drain at top, having the side slopes according to the foregoing table :—

For 1 to 1, or 12 inches in 1 foot—Add the width of the drain at bottom to double the depth, and the sum is the required breadth at top.

For ¾ to 1, or 9 inches in 1 foot—Add the width at bottom to one-and-a-half times the depth, and the sum is the required breadth at top.

For ½ to 1, or 6 inches in 1 foot—Add the width at bottom to the depth, and the sum is the required breadth at top.

Table IV. is useful in excavations for covered drains, foundations for walls, &c.

This table also enables the calculations to be extended to a drain or excavation of *any breadth at bottom*, by merely adding the cubic yards found for the extra width at bottom in this table, to the other quantity found. For instance, required the contents of a perch of excavation 18 feet in breadth at bottom, 6 feet deep, slopes 1 to 1. In table I. see 10 feet wide at bottom, 6 feet deep, will give 58½ cubic yards, and then referring to table IV. for the extra width, 8 feet, and 6 feet deep, gives 29¼; this added to 58½, we find 87¾ cubic yards in the statute perch.

There is a deficiency of ¼ cube yard, on account of fractions.

In the use of these tables it is presumed that the cross section of the ground where the drain has to be cut is *level land ;* if the drain has to be cut *on a slope,* the depth of the centre of the drain must be taken, in which case the rise on one side is balanced by the fall on the other.

The above tables can also be applied to embankments, reversing the arrangement, viz.,—taking the top of the embankment as the bottom of the drain ; an allowance, however, should be made for consolidation or settlement—perhaps as much as a tenth more soil should be allowed to form an embankment of a certain height and width than the quantity stated in the tables.

Redemption of rent charges for the advance of public money for draining landed estates:—

Term unexpired.		Redemption to be paid in respect of each £10 of Rent Charge.			
		£ Decimals.	In Sterling Money.		
½	Year	4·91612	£4	18	4
1	,,	9·74976	9	15	0
1½	,,	14·50232	14	10	0½
2	,,	19·17514	19	3	6
2½	,,	23·76957	23	15	4¾
3	,,	28·28693	28	5	8¾
3½	,,	32·72850	32	14	6¾
4	,,	37·09555	37	1	11
4½	,,	41·38935	41	7	9½
5	,,	45·61111	45	12	2¾
5½	,,	49·76204	49	15	3
6	,,	53·84334	53	16	10½
6½	,,	57·85617	57	17	1½
7	,,	61·80168	61	16	0½
7½	,,	65·68100	65	13	7½
8	,,	69·49524	69	9	10¾
8½	,,	73·24548	73	4	11
9	,,	76·93282	76	18	7¾
9½	,,	80·55829	80	11	2
10	,,	84·12295	84	2	5½
10½	,,	87·62780	87	12	6¾
11	,,	91·07385	91	1	5¾
11½	,,	94·46209	94	9	3
12	,,	97·79349	97	15	10½
12½	,,	101·06900	101	1	4½
13	,,	104·28956	104	5	9½
13½	,,	107·45609	107	9	1½
14	,,	110·56950	110	11	4¾
14½	,,	113·63067	113	12	7¼
15	,,	116·64049	116	12	9¾
15½	,,	119·59980	119	12	0
16	,,	122·50948	122	10	2¼
16½	,,	125·37035	125	7	5
17	,,	128·18322	128	3	8
17½	,,	130·94890	130	18	11¾
18	,,	133·66818	133	13	4¼
18½	,,	136·34188	136	6	10
19	,,	138·97065	138	19	5
19½	,,	141·55536	141	11	1¼
20	,,	144·09673	144	1	11¼
20½	,,	146·59544	146	11	0
21	,,	149·05229	149	1	0½

This table is calculated on the assumption that a yearly rent charge of £6. 10s., continued for a term of twenty-two years (but payable half-yearly), is equivalent to the sum of £100 in ready money.

Rent charges for advances of public money for draining landed estates, to be paid off in less than twenty-two years :—

Reduced Period.		Annual Rent for such Period, for each £6. 10s. of Rent Charge.			
		£. Decimals.	In Sterling Money.		
Annual Rent Charge if it is to last	21 Years	6·7091	£6	14	2¼
	20 ,,	6·9398	6	18	9½
	19 ,,	7·1958	7	3	11
	18 ,,	7·4812	7	9	7½
	17 ,,	7·8013	7	16	0¼
	16 ,,	8·1626	8	3	3
	15 ,,	8·5734	8	11	5½
	14 ,,	9·0441	9	0	10½
	13 ,,	9·5887	9	11	9¼
	12 ,,	10·2255	10	4	6¼
	11 ,,	10·9801	10	19	7¼
	10 ,,	11·8874	11	17	9
	9 ,,	12·9984	12	19	11½
	8 ,,	14·3895	14	7	9½
	7 ,,	16·1808	16	3	7½
	6 ,,	18·5724	18	11	5½
	5 ,,	21·9244	21	18	5¾
	4 ,,	26·9574	26	19	1¾
	3 ,,	35·3520	35	7	0½
	2 ,,	52·1508	52	3	0¼
	1 ,,	102·5666	102	11	4

This table is calculated on the assumption that a yearly rent charge of £6. 10s., continued for a term of twenty-two years (but payable half-yearly), is equivalent to the sum of £100 in ready money.

JOHN EWART,

Land Surveyor and Agricultural Architect and Engineer,

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